Detection of NO2 emissions using MIPAS

Anu Dudhia
Atmospheric, Oceanic and Planetary Physics, University of Oxford

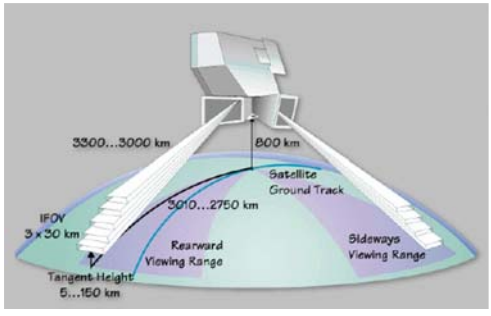
INTRODUCTION

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is a limb-viewing infrared fourier transform interferometers on the ESA Envisat satellite launched in 2002.

MIPAS makes global measurements of infrared spectra in the range 4-15μm at tangent heights from the mesosphere down to the mod-troposphere. From these spectra, vertical profiles of atmospheric temperature and composition, including stratospheric NO2, are routinely retrieved by ESA and several other groups, including Oxford.

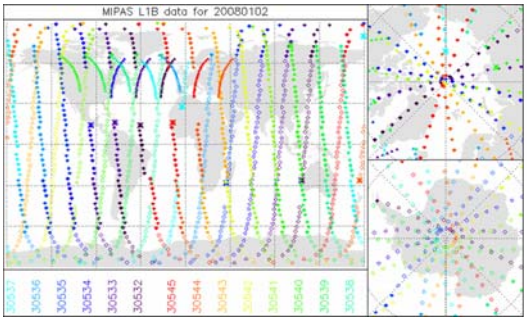
Here we examine the feasibility of retrieving NO2 concentrations in the upper troposphere from MIPAS spectra.

THE MIPAS INSTRUMENT

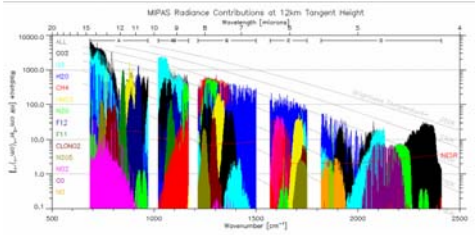


In normal operation MIPAS views rearward along the orbit track giving pole-to-pole coverage and approximately 14 orbits per day. However it also has the ability to view sideways, and such observations are occasionally scheduled to view east-west along the North Atlantic flight corridor as a special mode dedicated to detection of aircraft emissions. Such observations are not yet routinely processed.

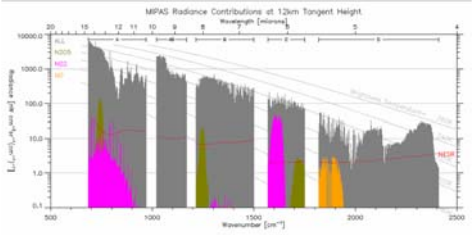
The plot below shows the coverage on 2nd January 2008, a day when such 'AE mode' observations can be seen as breaks from the normal observations following the orbit track.



THE MIPAS SPECTRUM



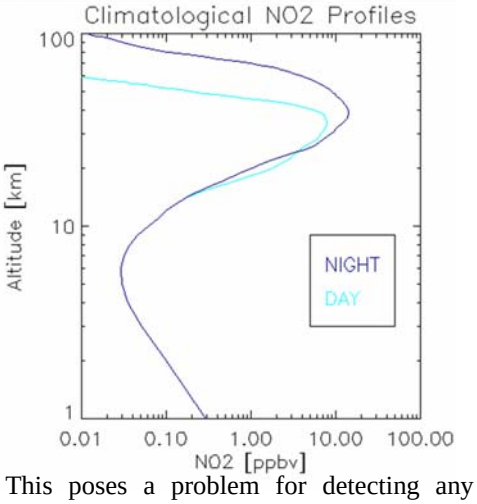
Above is a simulated MIPAS spectrum for a tangent height of 12km showing the spectral features associated with the main infrared emitting species in the atmosphere. Below is the same plot but just showing the NOx species.



The grey spectrum represents the total spectrum contributed by all emitting molecules and the red line the MIPAS noise level. On this basis, the NO2 feature between 1550-1650 cm^{-1} has been selected as the most likely to yield a detectable aircraft emission signature.

ATMOSPHERIC NO2

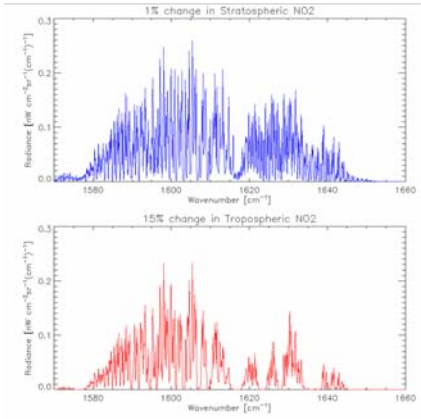
NO2 (and other NOx species) occur naturally in the atmosphere, and have maximum concentrations (measured in ppbv) in the mid-stratosphere.



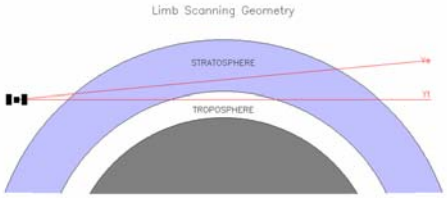
This poses a problem for detecting any enhancement in the upper troposphere from space: it has to be distinguishable from the relatively large stratospheric NO2 which will also contribute to the measurement.

NO2 SENSITIVITY

The plots below show the expected impact of variations in NO2 in the stratosphere and upper troposphere in the spectrum taken from a 12km tangent height (note the different perturbation sizes)



As expected the two signatures are very similar, making it difficult to assign any enhancement in the signal to a particular altitude along the limb path. However, with limb-scanning instruments such as MIPAS, additional measurements are also available which depend only on the stratospheric column, as shown below.



CONCLUSIONS

Assuming that the full NO2 band is used and the above viewing geometry, a linear least-squares-fit analysis suggests that the NO2 at 12km can be retrieved with a **precision of 3%** (i.e. that an aircraft-induced enhancement of 3% above background levels should be detectable).

However there are some important caveats

- No other errors, e.g. in temperature or interfering species (primarily H2O)
- The 'shape' of the stratospheric NO2 is assumed fixed and known
- In practice, using the entire NO2 band would be computationally prohibitive. (Operational retrievals tend to concentrate on a few 'microwindows' totalling 10-20cm^{-1} in bandwidth).